Intermountain Power Agency

Greenhouse Gas Reduction Feasibility Study

Task 1 – Improve Efficiencies

REVISED DRAFT REPORT
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1.0 Executive Summary

This is the first of six tasks to respond to the Intermountain Power Agency (IPA) and Southern California Public Power Authority (SCPPA) request to study, at a pre-feasibility level, the options available to reduce carbon emissions in the form of carbon dioxide (CO_2) from the coal fired Intermountain Power Project (IPP) located in south-central Utah. The focus of the first task was to study changes that could be made to existing IPP equipment or operations and maintenance (O&M) practices that could reduce these emissions.

None of the projects listed within this first task possess the ability to drastically affect the overall CO_2 footprint of IPP; however, they represent what is possible using readily available technologies and processes.

To address the effectiveness of the projects studied, two levels of carbon costs were addressed. The two values used in this work to study effectiveness were \$20/ton and \$40/ton of CO_2 emitted. (At the time of this report, there were a number of initiatives being considered at both a state and national level, including both a tax per ton as well as a cap-and-trade program that would result in IPP incurring costs within the range mentioned.) In total, approximately 30 projects were investigated using the assumptions discussed herein, with eight projects having a positive net financial benefit under a \$40/ton of CO_2 cost basis and five projects having a positive net financial benefit under a \$20/ton of CO_2 cost basis. Black & Veatch was unable to fully quantify the impact of one project because of scope considerations; it was the replacement of the cooling towers. Under a replacement scenario, the options available are numerous and must be studied in detail to accurately quantify them on an economic basis. However, Black & Veatch recommends that it be explored further in more detail.

The net benefit derived for each project is the annualized capital cost plus the increase in O&M costs versus the savings in fuel, emissions, and reliability. the total potential CO_2 savings has been estimated at 184,000 tons CO_2/year, which represents a net decrease of 1.3 percent if all cost-effective projects were pursued, including those already planned for implementation. Under the best case scenario, this effectively brings the CO_2 emissions rate of IPP down from ~1,950 lb CO_2/MWh to 1,925 lb CO_2/MWh versus the goal of 1,100 lb CO_2/MWh, as addressed in recent California legislation.

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Based on the pre-feasibility work discussed within this task, the eight most effective projects are summarized in the table below under the \$40/ton CO_2 scenario:

Project Description	Est Capital Cost (\$000)	CO_2 Reduction (tons/yr)	CO_2 Benefit (\$/yr)	Estimated Heat Rate Reduction (Btu/kWh)	Heat Rate Benefit (\$/yr)	Estimated Aux Load Benefit (MW)	Net Benefit (\$/yr)
Modification of PA Air Heater Sector Plates and Installation of Duplex Sealing System	\$418	26,501	\$1,060,036	6	\$423,495	2 40	\$1,457,575
Upgrade IPT Steam Path	\$13,333	41,597	\$1,663,874	29	\$664,735	0 00	\$1,273,714
Sliding Pressure Operation	\$0	14,798	\$591,922	10	\$236,479	0 00	\$832,580
VFD Motor for Condensate Pumps	\$1,312	7,734	\$309,341	0	\$123,585	1 04	\$330,149
Cycle Isolation Audit & Valve Repair/Replacement	\$120	4,160	\$166,387	3	\$66,473	0 00	\$224,435
LP Turbine Upgrade One Hood	\$27,000	40,706	\$1,628,237	28	\$650,497	0 00	\$130,229
Upgrade BFPT (Blades and Seals)	\$2,000	4,245	\$169,802	3	\$67,838	0 00	\$78,838
High Efficiency Motor for Coal Pulverizers	\$1,360	2,422	\$96,891	0	\$38,709	0 33	\$27,484
Summary Total *(Net Benefit Positive Only)*	**\$45,543**	**142,162**	**\$5,686,491**	**79**	**\$2,271,811**	**3.8**	**\$4,355,006**

In contrast, the following table provides information on the same projects, but under the \$20/ton CO_2 market model:

Project Description	Est Capital Cost (\$000)	CO_2 Reduction (tons/yr)	CO_2 Benefit (\$/yr)	Estimated Heat Rate Reduction (Btu/kWh)	Heat Rate Benefit (\$/yr)	Estimated Aux Load Benefit (MW)	Net Benefit (\$/yr)
Modification of PA Air Heater Sector Plates and Installation of Duplex Sealing System	\$418	26,501	\$530,018	6	\$423,495	2 40	\$927,557
Upgrade IPT Steam Path	\$13,333	41,597	\$831,937	29	\$664,735	0 00	\$441,777
Sliding Pressure Operation	\$0	14,798	\$295,961	10	\$236,479	0 00	\$536,619
VFD Motor for Condensate Pumps	\$1,312	7,734	\$154,670	0	\$123,585	1 04	\$175,479
Cycle Isolation Audit & Valve Repair/Replacement	\$120	4,160	\$83,194	3	\$66,473	0.00	\$141,242
LP Turbine Upgrade One Hood	\$27,000	40,706	\$814,119	28	\$650,497	0 00	-\$683,890
Upgrade BFPT (Blades and Seals)	\$2,000	4,245	\$84,901	3	\$67,838	0 00	-\$6,063
High Efficiency Motor for Coal Pulverizers	\$1,360	2,422	\$48,446	0	\$38,709	0 33	-\$20,961
Summary Total *(Net Benefit Positive Only)*	**\$15,183**	**94,789**	**\$1,895,780**	**48**	**\$1,514,767**	**3.4**	**\$2,222,674**

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2.0 Introduction

2.1 Background

In an effort to reduce the IPP carbon footprint, IPA retained Black & Veatch to assess available or emerging opportunities to reduce the overall CO_2 emissions rate for power that is produced in Utah but supplied to California markets by IPP. This includes plant capital projects, process modifications, and operational and/or maintenance adjustments. IPP's CO_2 emissions rate is estimated at approximately 1,950 lb of CO_2 per MWh. For IPP to meet the new regulated emissions limit of 1,100 lb of CO_2 per MWh, it would require a reduction of approximately 44 percent.

2.2 Objective

The primary objective of this task was to provide an overview of potential modifications to the existing IPP facility that would reduce total annual CO_2 emissions. This includes equipment upgrades or retrofits and cycle modifications. This objective is one small portion of the overall study being conducted for IPA that explores all viable options that could mitigate CO_2 emission including, but not limited to, Carbon Capture, Carbon Markets, and Renewable Cogeneration and/or Supplementation.

This report was written on a pre-feasibility level; any option identified as viable would require further work to reach actionable performance and economic impact data. Cost and benefit estimates for each identified option were based on data provided from multiple sources and include the following:

- Intermountain Power Service Corporation (IPSC).
- General Electric (via IPSC).
- Alstom Power (via IPSC).
- Toshiba Corporation (via IPSC).
- Black & Veatch.
- Multiple State Agencies (CA, KS, IA).
- American Society of Mechanical Engineers (ASME).
- The United States Environmental Protection Agency (USEPA).

2.3 Approach

Black & Veatch implemented a systematic approach to ensure that no viable efficiency improvement projects were omitted. First, a data request was submitted to IPSC. This included capital budget information that Black & Veatch used to identify

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planned projects as well as technical information regarding the design and past performance of the units that was used to identify and quantify the benefit of additional project opportunities.

With this data available to Black & Veatch engineers, the next step was to identify projects that were already being planned that had an efficiency impact. Current IPP capital budget items were reviewed to identify the existing projects with CO_2 emissions reduction potential. Black & Veatch then assessed the degree of expected efficiency improvement and CO_2 reduction.

Next, Black & Veatch subject matter experts assembled a list of potential efficiency improvement projects on a system-by-system basis. This list was used to facilitate the next step, which was to conduct the evaluation leveraging both internal and external resources as well as subject matter experts.

To effectively manage the screening of the identified projects, they were organized into the following categories. Each project that demonstrated positive net benefits was assessed using these same categories:

1. Capital Improvements.
2. Maintenance Repair/Replace Strategies.
3. Operations Support Systems.
4. Operations Practices.

2.3.1 Category No. 1 – Capital Improvements

These types of projects are generally larger in scale, funded through a capital budget process, and have defined benefits and costs. These projects result in specific improvements in efficiency and therefore CO_2 reduction. An example of this type of project would be a major turbine design modification that results in an improvement in turbine cycle efficiency and heat rate.

2.3.2 Category No. 2 – Maintenance Repair/Replace Strategies

This type of project is a somewhat unique category established to identify maintenance projects that are optional or have elements that are optional. These optional components are what distinguish these projects from routine maintenance, which was not included because these projects are geared only at restoring degraded efficiency. In order to qualify as a project for consideration, this type of project must involve a specific and defined change in maintenance practices or plans such that the change in CO_2 emissions is a direct result.

The general type of project defined by this category is one in which there is a higher cost option to perform the maintenance (or replacement) that offers a specific heat rate or efficiency benefit. An example of this type of project would be implementation of a program or strategy of ensuring that when there are options in terms of the efficiency rating of motors, the practice would be to purchase the equipment that offered the highest possible rating, likely at a higher capital cost.

2.3.3 Category No. 3 – Operations Support Systems

Operations support systems were defined as projects that aid the plant operations staff in utilizing the plant equipment in a more efficient manner. These may be capital or O&M expense-funded projects, but are unique in that they may not require a major modification to a specific system or piece of equipment. Instead, they affect the unit through providing operational information or guidance that results in improved unit performance. Common examples of this type of project are performance monitoring or combustion optimization systems. These systems can be advisory or closed-loop (providing direct control of the process), but in either case require some form of operator interaction.

2.3.4 Category No. 4 – Operations Practices

Modifications to the plant's operating practices offer the potential for reducing the amount of CO_2 emissions by eliminating redundant equipment or other changes that result in improved efficiency. An example of this type of opportunity would be removing one pump or fan from service when operating at a reduced load. These types of projects often have the potential to reduce parasitic loads. However, they also have a tendency to reduce flexibility and increase the probability of unit trips. As a result, it is difficult to ensure that operators will regularly and consistently apply these practices, especially when there may be unique or mitigating circumstances that increase that probability of a forced outage.

3.0 Improvement Project Summary

As described in the previous section, the process of identifying improvement projects included a review of planned capital projects for the next 3 years. Further brainstorming was conducted at an onsite meeting with IPSC staff to gain insight into those planned improvements and to add to the list using ideas previously considered but not approved and ideas that had not been considered economically feasible according to the standard economic assessment requirement of IPSC. Each resulting project where the initial cost/benefit analysis showed a positive net benefit at \$40/tonCO_2 is described herein.

3.1 Capital Improvements

3.1.1 IP Turbine Dense Pack Upgrade (Tentatively Planned)

High-pressure (HP) turbine dense packs have already been installed at IPP, and IPSC staff is now tentatively considering intermediate-pressure (IP) turbine dense pack upgrades for implementation between 2011 and 2013, if they can be economically justified. IPSC staff has received two proposals, one from Alstom and a second from Toshiba Corporation specifically discussing the IP turbine upgrade. The scopes of both proposals include modifications to the IP turbine and to the low-pressure (LP) turbine last-stage blades. Both reports estimate improved heat rates on the order of 2.5 percent when corrected, for no further increase in generation due to transmission limitations. At present, the transmission lines emanating from IPP are at design capacity and cannot transport any further increases in electrical load. As such, any further capital expenditures where an increase in generated power is possible must be properly adjusted to reflect the efficiency improvement only.

Further analysis was conducted to determine what proportion of the heat rate improvement was directly attributed to the IP turbine modifications. The finalized value was determined to be between 0.2 and 0.4 percent, equating to an average heat rate improvement of 29 Btu/kWh.

From the perspective of reductions in greenhouse gas emissions, this project has the potential to reduce IPP's overall CO_2 profile by 41,600 ton/year.

No cost information was included with the Alstom and Toshiba proposals; however, Black & Veatch in-house estimates place IP turbine modifications similar in scope to those proposed at IPP at \$6.65 million/turbine, for a total cost of \$13.3 million for both units. This estimate was considered accurate as of September 2007, though some fluctuation in material costs may have shifted this figure higher.

3.1.2 Pulverizer Modifications

Performance improvements to the pulverizers are another possible way to improve the CO_2 footprint of IPP. In total, Units 1 and 2 have 16 Babcock & Wilcox (B&W) 89G pulverizers, 14 of which (seven per unit with one reserve) are typically required for full load operation. Recent degradations in coal quality along with the HP turbine upgrade now occasionally require operation of the reserve mill to achieve full load operation, though this is not a common occurrence.

B&W provided a report detailing possible modifications that could be completed to improve overall pulverizer performance, including upgraded grinding elements, throat modifications, and possible installation of rotating classifiers. It addresses all of the known options available to IPA, but does not compare those options on a CO_2 reduction potential. Furthermore, this is a project already planned for the 2012 to 2016 time frame and was justified through the expected improvement in maintenance costs associated with mill maintenance.

Statistically, it is difficult to predict the end-game performance of specific mill modifications, but from the perspective of reducing the CO_2 profile of IPP, the chief CO_2 reducing mechanism for this opportunity would be through any residual reduction in total auxiliary power consumption by the mills.

B&W stated in its proposal that it may be possible to return the units to six-mill operation (original design condition). This statement is considered optimistic and, while IPSC and Black & Veatch consider six-mill operation possible post-modification, it would likely be unsustainable over long-term operation.

Under the best case scenario, this project has the potential to reduce auxiliary power by 0.60 MW per unit, the equivalent of one mill per unit. However, Black & Veatch would estimate the sustainable portion of this to be no more than 50 percent of this value, or 0.30 MW. A reduction of 0.30 MW in auxiliary power on both Units 1 and 2 has the potential to reduce CO_2 emissions by 4,400 tons/year.

3.1.3 Replacement of Primary Air Heater Baskets and Seals

Primary air (PA) heater modification is another capital project that has the potential to reduce IPP's overall CO_2 profile. The PA fans are dual-speed capable and were originally designed to operate at the lower of these two options (2,100 hp). However, the combination of PA heater leakage (estimated to be as high as 40 percent of flue gas flow) and the HP turbine dense pack upgrade have led to the need to operate the fans continuously at their high speed setting, drawing approximately 1.2 MW in greater power for each fan.

Black & Veatch has reviewed the design modification proposal submitted to IPSC by Alstom in August of 2002. The primary modifications suggested included upgrading the current air heater seals to duplex seals and the installation of modified heat transfer surfaces to reduce fouling. Alstom states that a 30 percent reduction in current leakage is possible with duplex sealing technology, and internal Black & Veatch documents suggest that this estimate is conservative.

The original cost estimates were performed from the standpoint of improved heat transfer and boiler efficiency as the primary method of payback for the PA heater upgrade. However, this project now has the potential to permit full load operation while operating the PA fans at their lower set point. This may ultimately remove 2.4 MW in auxiliary power requirements for each unit.

Black & Veatch estimates indicated a potential for these modifications to permit low-speed operation, though a full analysis by the vendor should be completed to determine the detailed performance differentials. Overall, should PA fan operation permit full load generation at the low-speed setting, Black & Veatch estimates a total CO_2 reduction potential of 26,500 ton/year for this project.

One final comment on this project is in regard to the air heater basket upgrade planned for 2009 to 2011. Black & Veatch did not evaluate the impact of this project independent of the already planned basket modifications, and the CO_2 reduction estimates should be considered reflective of both air heater modifications. All air heater upgrade costs and overall benefits have therefore been collectively reported through this evaluation.

3.1.4 Variable Frequency Drives for Condensate Pumps

This project examines adding a variable frequency drive (VFD), also known as adjustable speed drive, an electronic controller that reduces electrical energy consumption by properly matching the pump motor speed to load demand. The units operate two of the three pumps at full load, so the VFD benefit is estimated that two pumps would run at 80 percent capacity. This results in savings of 1,044 kW across both units, at a capital cost of $1,312,500. The savings of 1,044 kW in auxiliary load is the chief mechanism for CO_2 reduction with this project. Lower auxiliary power load translates directly into less fuel burned. If this project is considered feasible, further study may be required to more accurately detail the true auxiliary power benefit, but based on the 1,044 kW reduction for both units, a total CO_2 reduction of 7,700 tons CO_2/year would be possible.

3.1.5 Generator Rewind

Both generators on Units 1 and 2 are planned for rewind in the 2009 to 2011 time frame. The original estimate returned to IPSC from GE regarding costs and efficiency improvements quoted the overall efficiency improvement as 454 kW, equating to an overall CO_2 reduction of 3,700 tons/year.

3.1.6 Boiler Feed Pump Turbine Upgrades

Because of the size of the IPP units, the boiler feed pump turbines are another source of possible efficiency improvement. Black & Veatch conducted a brief analysis, examining only the typical benefit of seal replacements and last-stage blade replacement. The overall benefit of this project was estimated to be marginal and was only positive under the $40/ton CO_2 market scenario. Furthermore, the estimated heat rate improvement that this modification may provide was between 3 and 5 Btu/kWh and, as such, more detailed analysis would be necessary to fully quantify the overall benefit under specific CO_2 market scenarios. The total potential CO_2 reduction for this project was estimated at 4,200 tons CO_2/year.

*3.1.7 Replacement of Cooling Towers**

The cooling towers have historically operated at a lower efficiency due to their seismic design. Several cooling tower original equipment manufacturers (OEMs) have been working to improve operating efficiency over the years through modifications, but to no avail. One option not explored, though showing potential, would be to replace the existing towers with modernized towers that should provide for improved air distribution and lower air inlet velocities – both translating into improved operating efficiency.

This project was not part of the original set of efficiency projects, and given the numerous options available, Black & Veatch did not attempt to cost justify this project as part of this pre-feasibility study. That said, Black & Veatch recommends this project be explored in greater detail.

3.2 Maintenance Repair/Replace Strategies

3.2.1 Cycle Isolation Audit and Valve Repair/Replacement

Historically, cycle isolation audits are not part of typical plant operations and, when conducted, result in the identification of multiple instances of cycle inefficiencies through degraded valves.

Black & Veatch has been involved in numerous cycle isolation audits over the years, and typical results are the identification of 10 to 20 valves/unit operating in a manner that compromises overall cycle efficiency. Typically, the estimates on overall heat rate improvement range between 0.3 and 0.8 percent.

In the case of IPP, the effectiveness of a cycle isolation audit must be tempered with the typical results noted at other facilities due to the highly proactive nature of the current operations staff. Both units are walked down on a regular basis, where engineers continually search out the types of cycle inefficiencies normally identified during a formal cycle isolation audit. While degraded valve performance is not a visible inefficiency, hot drains or leaking steam traps are items that Black & Veatch would expect unit walk-downs to identify on a consistent basis.

Black & Veatch estimates that, should a full cycle isolation audit be completed along with any recommended repairs on both IPP units, the total improvement to operating heat rate would be on the order of 3 to 8 Btu/kWh. This results in a predicted IPA CO_2 reduction of 4,000 ton CO_2/year. However, this is an operationally dependent CO_2 reduction. One cycle isolation audit will not permanently achieve this reduction. Recurring scheduled audits would also be necessary to ensure that the savings are maintained.

Further economic impact information along with CO_2 reduction scenarios has been provided in Appendices A and B of this report.

3.2.2 High Efficiency Motor for Coal Pulverizers

This project involves replacing the existing standard pulverizer motors with one that has a higher efficiency. A review of the motor data provided shows that the motors are 800 hp and have a nominal efficiency rating at full load of 93 percent, 3/4 load of 92.9 percent, and 1/2 load at 92.9 percent. The motor efficiencies could potentially be increased to a range of 95 to 96.5 percent. Increasing the motor efficiency from 93 to 96 percent would save 23.3 kW per motor. With each unit having seven pulverizers operating, the total savings across both units amounts to 327 kW at a cost of $1,360,000. Should the reduction in auxiliary power be achieved, Black & Veatch estimates that this project has the potential to reduce annual CO_2 production by 2,400 tons/year.

3.2.3 Compressed Air Leakage Audit

Compressed air systems are another typical source of operating inefficiency. Conversations with plant personnel suggest that leakage may be high, based on the observation that three compressors are in continuous operation, when historically, the plant has been able to meet the compressed air demand with two compressors in operation.

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The total operating power of the compressed air system is 2,800 hp and, using system demand signals captured through the plant data historian, it was estimated that the plant is operating at 82 percent of this capacity. Typically, capacity estimates are based on total air demand as to the available compression power, but in the absence of air flow/volume data, supply power has been used as a proxy to determine demand.

The total cost of operating the compressed air system for 2007 was estimated to be $415,000/year. This cost assumes 90 percent efficient compressor motors and a total cost of power at $0.025/kWh (Plant Generation Cost). Under a market scenario of $0.05/kWh (Retail Cost), the estimated operational cost is $830,000/year. A recent compressed air system audit was completed, which estimated these operational costs to be near $770,000/year, indicating relatively good agreement between the two.

The Iowa Department of Natural Resources has conducted compressed air system audits over the past 10 years, and summary statistics indicate the nominal leakage rate identified within the manufacturing industry to be near 30 percent. This figure is corroborated by the US Department of Energy. Both of these figures are in agreement with plant knowledge that the compressed air system has historically been able to operate under two compressors as opposed to current operation, which averages 3.25 compressors during the year.

Black & Veatch estimates that, should approximately 80 percent of the identified leaks be repaired, a total cost savings base of $100,000/year could be realized.

Capital costs associated with this effort were estimated at $50,000 for the initial audit and another $50,000 for the effort to repair the identified leaks; however, further detail has been provided, with the onsite evaluation completed on February 8, 2008.

Ultimately, the primary goal is to return to two-compressor operation and repair the identified leaks, which should put IPA well on its way to achieving this goal. Black & Veatch estimates that, should the plant return to two-compressor operation, the total CO_2 savings would be 4,500 tons/year. IPSC is also relatively confident that new dryers will also be required to achieve this goal and Black & Veatch has scaled the overall assessment costs to reflect this requirement. Further economic information on this project has been provided in Appendices A and B of this report.

3.3 Operations Support Systems

Closed loop combustion optimization software uses neural network technology along with automated Digital Control System (DCS) biasing to optimize boiler efficiency in real time. IPP benefits from several factors that will improve the chance of success with a neural net system. Over-fired air (OFA) controls have been strong levers for neural net-based combustion optimization, and the plant has OFA ports with inlet damper

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control. Another plus is that the plant has the ability to adjust coal flow manually to each burner through a series of coal flow restrictors. The plant also has the ability to control airflow manually to individual burners through air hood adjustments. Placing actuators on these controls would provide a neural net system with maximum control over the air-to-fuel ratio of each burner.

DCS logic modifications are required. Operations staff must learn to take comfort in allowing the neural network to actively learn and adjust the boiler biases. Use of the neural net will require close monitoring of unburned carbon in ash, but the plant already appears to do this well.

Adaptive neural net systems produce the greatest impact where they have control over air and fuel mixtures down to a fine level. The full benefits of this level of control are only realized if the plant has adequate feedback signals to allow the neural net to sense changes made to the available controls. For instance, individual fuel and air controls at each burner provide tremendous levers for a neural net system; however, the effect of the levers is reduced if the neural net does not receive feedback about the air/fuel mixture through a grid of CO_2 measurements.

The plant took steps to improve combustion over the last several years by adjusting air and fuel flows to the individual burners. A certain amount of optimization has already been attained, thus reducing the amount of optimization left to achieve through a neural net system. Typically, the benefits of manual optimization are greatest immediately after tuning is complete. The further removed the plant is from manual tuning, the smaller is the benefit because of changing conditions such as equipment aging and wearing. Adaptive neural net-based combustion optimization tends to provide long-term benefits through regular and automatic training sessions that allow the system to adapt to changing conditions of plant equipment.

Typical results noted by Black & Veatch on similar boilers are presented in Table 1:

Table 1: Historical Performance of CombustionOpt® Installations

	NOx Reduction	Boiler Efficiency Increase
B&W Wall Fired Boiler	6.67%	0.135%
Front and Rear Wall Fired Boiler	9.58%	0.013%
All Wall Fired Boilers	7.36%	0.057%

All boilers in Table 1 had nitrogen oxide (NO_x) reduction as the main objective, with boiler efficiency as a secondary objective. With the objectives switched to focus primarily on boiler efficiency, Black & Veatch expects IPP to achieve greater boiler efficiency improvements than those shown in Table 1. Therefore, a boiler efficiency improvement of 0.135 percent (or heat rate improvement of 0.16 percent) is expected. Should this system provide a 0.135 percent improvement to operating heat rate, fuel consumption should decline proportionally, resulting in an estimated reduction of 18,700 ton CO_2 per annum.

3.4 Operations Practices

Sliding pressure operation was also analyzed as a possible method to improve overall cycle efficiency. The main advantage of variable pressure operation is that the turbine first-stage temperature remains relatively constant across the load range, which shortens startup times, increases turbine rotor life, and mitigates throttling losses. There are, however, realities that must be considered when evaluating this option and they are primarily focused on the required response time by IPA power purchasers. Typically, generators providing power to a retail market must comply with specific response times once the signal to increase or decrease power is received. Operating under a sliding pressure mode of operation effectively lengthens this response time by two times or greater. This concern will ultimately determine whether this project is truly feasible for IPP.

Adjusting the mode of operation from throttled to sliding pressure is a cost neutral option to increase overall efficiency since no system modifications would be required.

Using the updated Alstom heat balance, thermal kit data, and 1 year of plant operating data, an estimate on the relative increase to cycle efficiency under valves wide open (VWO) operation was calculated to be 10 Btu/kWh, if applied to all modes of operation. This resulted in a CO_2 savings of 14,800 ton/year and a net operating benefit of $251,575/year. Further numeric data has been summarized in Appendices A and B of this report.

Appendix A: Table of All Projects Reviewed ($20/ton CO_2)

	Unit	Plant Contact	B&V Contact	Project Status	Project Cate-gory	Year Planned/ Finished	Est Capital Cost ($000)	Added O&M Cost ($/yr)	Estimated Aux load benefit (MW)	Estimated Heat Rate Reduction (Btu/kWh)	EFOR Improve-ment (%)	CO_2 Reduction (ton/yr)	Heat Rate Benefit ($/yr)	CO_2 Be ($/yr
Plates and Installation of	IPP		Jeff K	Opportunity	1		$418	$0	2 400	6	0	26,501	$423,495	$530,
	IPP	Aaron Nissen	Jeff K	Opportunity	1	2011-2013	$13,333	$0	0 000	29	0	41,597	$664,735	$831,
	IPP		Jeff K	Opportunity	4		$0	$0	0 000	10	0	14,798	$236,479	$295,
	IPP	Mike Nuttall	Curtis R	Opportunity	1		$1,312	$0	1 044	0	0	7,734	$123,585	$154,
Replacement	IPP		Jeff K	Opportunity	2		$120	$0	0.0	3	0	4,160	$66,473	$83,1
	IPP		Jeff K	Opportunity	1		$27,000	$0	0	28	0	40,706	$650,497	$814,
	IPP		Jeff K	Opportunity	1		$2,000	$0	0.000	3	0	4,245	$67,838	$84,9
zers	IPP	Mike Nuttall	Curtis R	Opportunity	2		$1,360	$0	0.327	0	0	2,422	$38,709	$48,4
ly if cooling tower	IPP	Mike Nuttall	Curtis R	Abandoned	1		$0	$0	0 000	0	0	0	$0	$0
	IPP	Mike Nuttall	Curtis R	Abandoned	1		$0		0 000			0	$0	$0
	IPP			Abandoned	1							0	$0	$0
	IPP	Mike Nuttall	Curtis R.	Abandoned	1		$0		0 00			0	$0	$0
m to Allow Less than 3-	IPP			Abandoned	1							0	$0	$0
ncreased steam	IPP			Abandoned	1							0	$0	$0
	IPP			Opportunity	1							0	$0	$0
	IPP	Mike Nuttall	Curtis R	Abandoned	1				0.000			0	$0	$0
	IPP	Mike Nuttall	Curtis R	Abandoned	1				0 000			0	$0	$0
tch) and/or Motors	IPP	Mike Nuttall	Curtis R	Abandoned	2		$0		0 000			0	$0	$0
	IPP	Jerry Hintze	Jeff K.	Abandoned	1		$0		0 000	0	0	0	$0	$0
D)	IPP	Mike Nuttall	Curtis R	Opportunity	2		$346		0.051			378	$6,037	$7,5
	IPP		Jeff K	Abandoned	1		$500	$25,000	0.0	0	0	0	$0	$0
	IPP	Jerry Hintze	Jeff K	Abandoned	1		$6,267		0 750	0	0	5,556	$88,782	$111,
	IPP		Jeff K	Opportunity	1		$54,231	$0	0	49	0	71,235	$1,138,370	$1,424
uel	IPP		Jeff K	Opportunity	1		$26,000	$0	0 000	0 19	0	276	$4,414	$5,5
	IPP		Jeff K.	Opportunity	1		$81,346	$0	0 0	53.0	0	77,051	$1,231,299	$1,541
	IPP		W Johnson	Abandoned	1									

IP12_002521

Appendix B. Table of All Projects Reviewed ($40/ton CO_2)

	Unit	Plant Contact	B&V Contact	Project Status	Project Cate-gory	Year Planned/ Finished	Est Capital Cost ($000)	Added O&M Cost ($/yr)	Estimated Aux load benefit (MW)	Estimated Heat Rate Reduction (Btu/kWh)	EFOR Improve-ment (%)	CO_2 Reduction (ton/yr)	Heat Rate Benefit ($/yr)
ter Sector Plates and Installation of	IPP		Jeff K	Opportunity	1		$418	$0	2 400	6	0	26,501	$423,495
	IPP	Aaron Nissen	Jeff K	Opportunity	1	2011-2013	$13,333	$0	0.000	29	0	41,597	$664,735
ı	IPP		Jeff K	Opportunity	4		$0	$0	0 000	10	0	14,798	$236,479
Pumps	IPP	Mike Nuttall	Curtis R	Opportunity	1		$1,312	$0	1 044	0	0	7,734	$123,585
lve Repair/Replacement	IPP		Jeff K.	Opportunity	2		$120	$0	0 0	3	0	4,160	$66,473
lood	IPP		Jeff K	Opportunity	1		$27,000	$0	0	28	0	40,706	$650,497
d Seals)	IPP		Jeff K	Opportunity	1		$2,000	$0	0.000	3	0	4,245	$67,838
oal Pulverizers	IPP	Mike Nuttall	Curtis R	Opportunity	2		$1,360	$0	0.327	0	0	2,422	$38,709
Pumps (only if cooling tower	IPP	Mike Nuttall	Curtis R	Abandoned	1		$0	$0	0 000	0	0	0	$0
	IPP	Mike Nuttall	Curtis R	Abandoned	1		$0		0 000			0	$0
	IPP			Abandoned	1							0	$0
ıp Motors	IPP	Mike Nuttall	Curtis R	Abandoned	1		$0		0 00			0	$0
ıoval System to Allow Less than 3-	IPP			Abandoned	1							0	$0
allow for increased steam	IPP			Abandoned	1							0	$0
stem	IPP			Opportunity	1							0	$0
ID Fans	IPP	Mike Nuttall	Curtis R	Abandoned	1				0 000			0	$0
FD Fans	IPP	Mike Nuttall	Curtis R	Abandoned	1				0 000			0	$0
(variable pitch) and/or Motors	IPP	Mike Nuttall	Curtis R.	Abandoned	2		$0		0 000			0	$0
Reduce dP)	IPP	Jerry Hintze	Jeff K	Abandoned	1		$0		0 000	0	0	0	$0
ighting (LED)	IPP	Mike Nuttall	Curtis R	Opportunity	2		$346		0 051			378	$6,037
ne to DC	IPP		Jeff K	Abandoned	1		$500	$25,000	0 0	0	0	0	$0
	IPP	Jerry Hintze	Jeff K	Abandoned	1		$6,267		0 750	0	0	5,556	$88,782
loods	IPP		Jeff K	Opportunity	1		$54,231	$0	0	49	0	71,235	$1,138,370
r Startup Fuel	IPP		Jeff K	Opportunity	1		$26,000	$0	0.000	0 19	0	276	$4,414
Hoods	IPP		Jeff K.	Opportunity	1		$81,346	$0	0.0	53 0	0	77,051	$1,231,299
	IPP		W Johnson	Abandoned	1								

Appendix C: Table of All Planned Projects Reviewed ($20/ton CO_2)

	Unit	Plant Contact	B&V Contact	Project Status	Project Cate-gory	Year Planned/ Finished	Est Capital Cost ($000)	Added O&M Cost ($/yr)	Estimated Aux load benefit (MW)	Estimated Heat Rate Reduction (Btu/kWh)	EFOR Improve-ment (%)	CO_2 Reduction (ton/yr)
ization System	IPP	Aaron Nissen	Greg T.	Planned	3	2012-2014	$800	$50,000	0.0	12.9		18,719
	IPP	Jerry Hintze		Planned	1	2009-2013						0
	IPP	Aaron Nissen	Jeff K.	Planned	1	2009-2011	$0	$0	0.0	0.0	0.0	0
	IPP	Jerry Hintze	Curtis R	Planned	1	2009-2011	$14,200	$0	0.500	0	0	3,704
/Replacement	IPP	Jerry Hintze	Jeff K	Planned	2	2008	$200		0.7			5,141
hroat and Static Classifiers	IPP	Aaron Nissen	Jeff K.	Planned	1	2012-2016	$10,000		0.600	0		4,445

Appendix B. Table 5. All Planned Projects Reviewed ($10/ton CO_2)

	Unit	Plant Contact	B&V Contact	Project Status	Project Cate-gory	Year Planned/ Finished	Est Capital Cost ($000)	Added O&M Cost ($/yr)	Estimated Aux load benefit (MW)	Estimated Heat Rate Reduction (Btu/kWh)	EFOR Improve-ment (%)	CO_2 Reduction (ton/yr)
ıization System	IPP	Aaron Nissen	Greg T.	Planned	3	2012-2014	$800	$50,000	0.0	12 9		18,719
	IPP	Jerry Hintze		Planned	1	2009-2013						0
	IPP	Aaron Nissen	Jeff K.	Planned	1	2009-2011	$0	$0	0.0	0.0	0 0	0
	IPP	Jerry Hintze	Curtis R.	Planned	1	2009-2011	$14,200	$0	0.500	0	0	3,704
/Replacement	IPP	Jerry Hintze	Jeff K.	Planned	2	2008	$200		0.7			5,141
hroat and Static Classifiers	IPP	Aaron Nissen	Jeff K.	Planned	1	2012-2016	$10,000		0.600	0		4,445